ASTHROS

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Astrophysics Stratospheric Telescope for High Spectral Resolution Observations at Submillimeter-wavelengths

Jet Propulsion Laboratory
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January 2019 IR SIG Splinter Session

Why Balloons? FIR Atmospheric Absorption!

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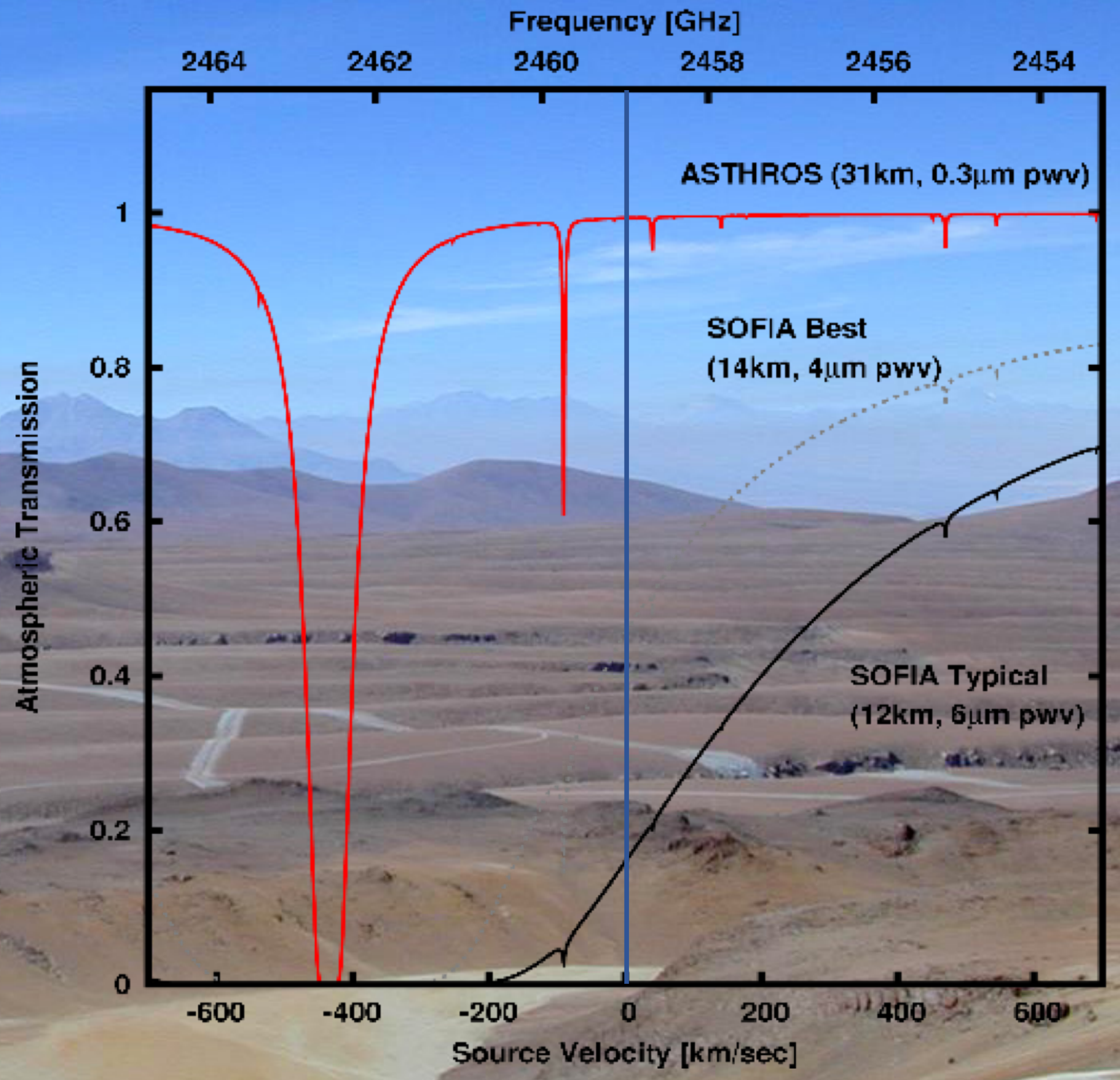
- The far infrared part of the electromagnetic spectrum is severely obscured by the Earth's atmosphere
- Observations at SOFIA altitudes enable observations of key lines, e.g [CII]
- But atmospheric absorption is still a problem at SOFIA altitudes which severely restricts observations of several lines and/or astronomical sources.
- The [NII] 122 micron line is significantly obscured by Earth's atmosphere at SOFIA altitude
- But at balloon altitudes the atmosphere is transparent for this line and large scale observations of this line are possible



ASTHROS Mission Overview

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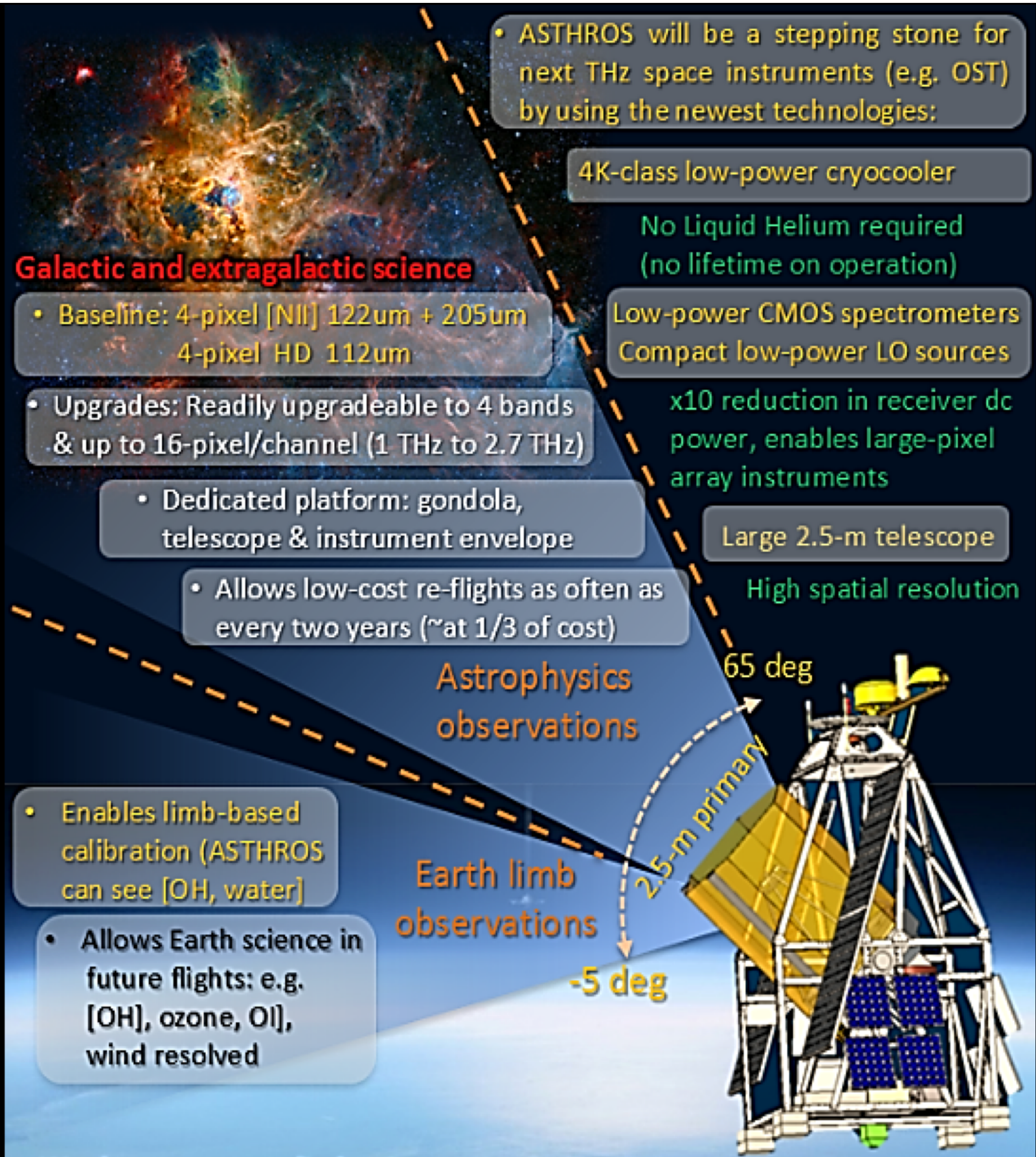
The Astrophysics Stratospheric Telescope for High Spectral Resolution Observations at Submillimeter-wavelengths (ASTHROS) is a suborbital balloon mission to enable detailed three-dimensional mapping of *ionized* gas in star forming regions in the Milky Way **and external galaxies** via simultaneous observations of the [NII] 122μm (2.675 THz) and 205μm (1.461 THz) fine structure lines of ionized nitrogen.

ASTHROS includes a **2.5m telescope** carried by a zero pressure balloon to a flight altitude of 40 km (130,000 feet) and will produce high spectral resolution, high spatial dynamical range maps of the ionized gas component in a selected sample of star forming regions during an Antarctica flight in Dec. 2023.

ASTHROS will also demonstrate key technology and science applications necessary for future NASA space missions



ASTHROS Science Overview

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- **Star formation is an inefficient process** in our Universe in which only a small percentage of the available interstellar material is converted into stars

- **Radiative and mechanical feedback** (SNe, stellar winds, etc) from newly formed massive stars is thought to be **a key process that regulates star formation in galaxies**

- **When massive stars form, they ionize surrounding material**, creating ionized hydrogen, or HII regions

- **The structure of HII regions is the reflection of the effect of different stellar feedback processes**

- **A 3-dimensional determination of the density structure of HII regions is crucial for the determination of the impact that stellar feedback has on the ISM**

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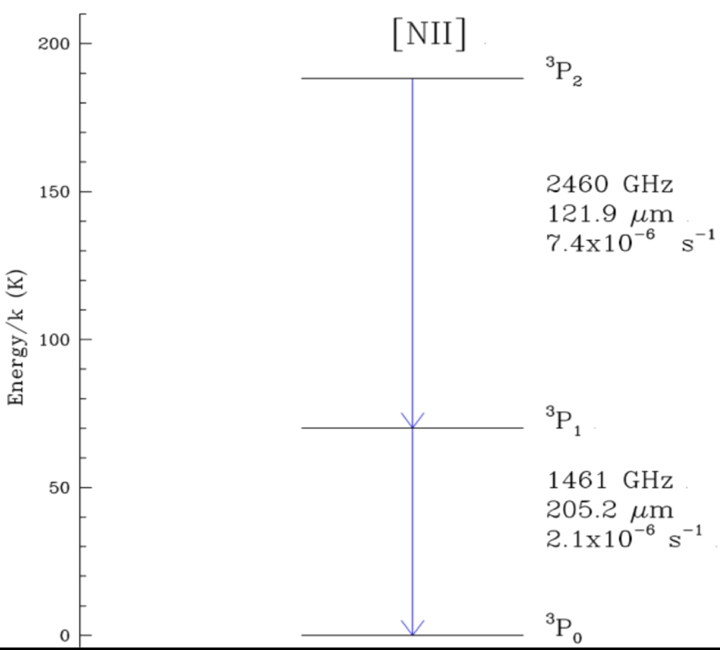
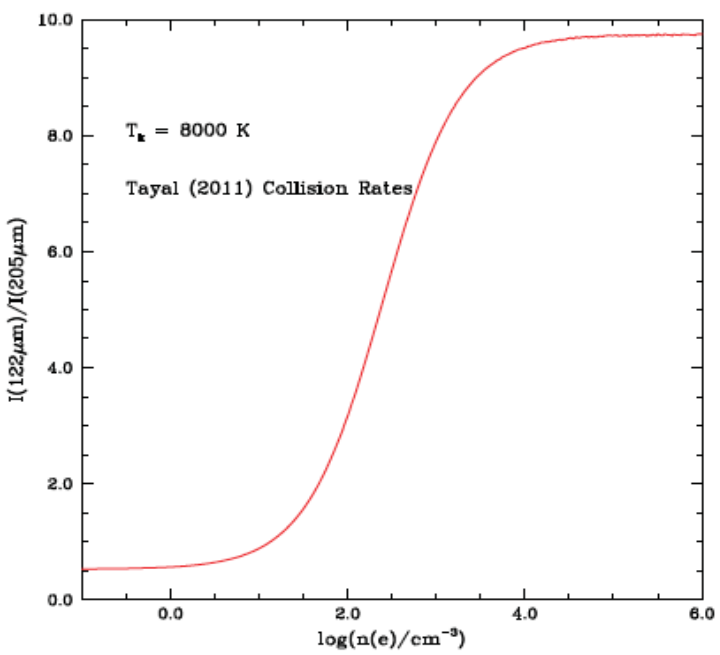
- Far-infrared **fine structure lines of ionized nitrogen are excellent tracers of the density structure and dynamics of HII regions**
- **There are two transitions of ionized nitrogen** at 122 microns and 205 microns wavelength
- **Nitrogen** IP is 14.5 eV so **found only in regions where H is completely ionized**



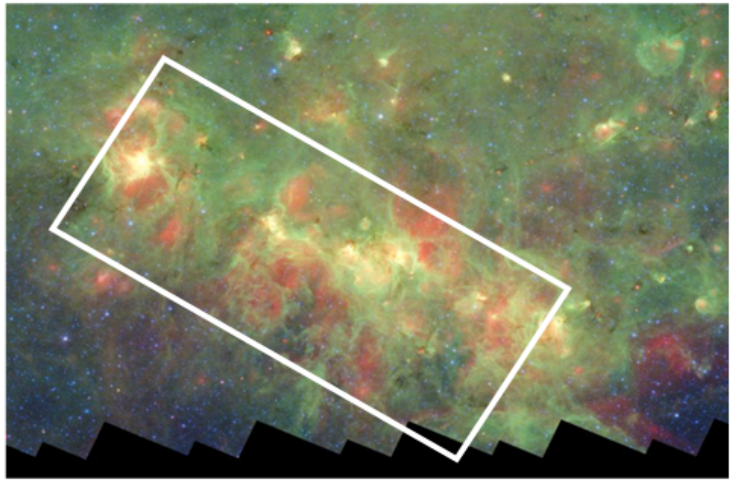


- **The ratio of the [NII] 122 micron to 205 microns line is a sensitive probe of the electron density**
- **With electron densities derived from ionized nitrogen and the velocity information provided by high spectral resolution observations, we can determine the 3D structure and kinematic of HII regions** and understand the role of feedback in these regions

ASTHROS Science Overview

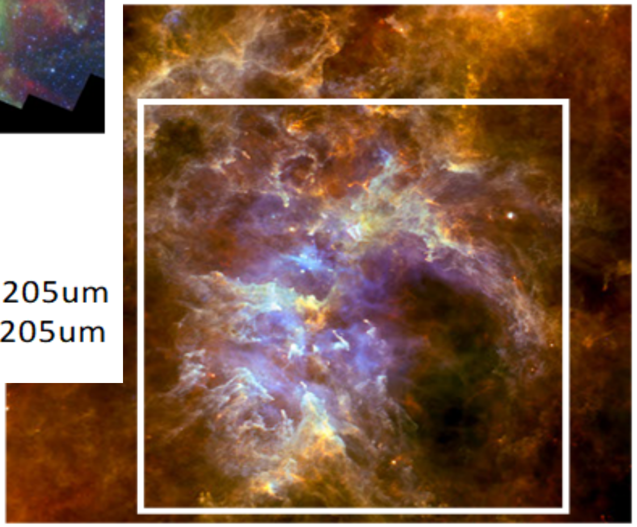
- **ASTHROS will produce high dynamic range, large scale maps** of two Galactic star forming regions, G336.2-0.2 and the Carina Nebula
- G333.6-0.2 is at a relatively early stage of evolution, before the action of supernova explosions, while the Carina region has clearly been affected by supernovae
- **By comparing the ionized gas distribution in these two regions, we will determine the relative effect of different stellar feedback mechanisms on the ISM.**

G336.2-0.2



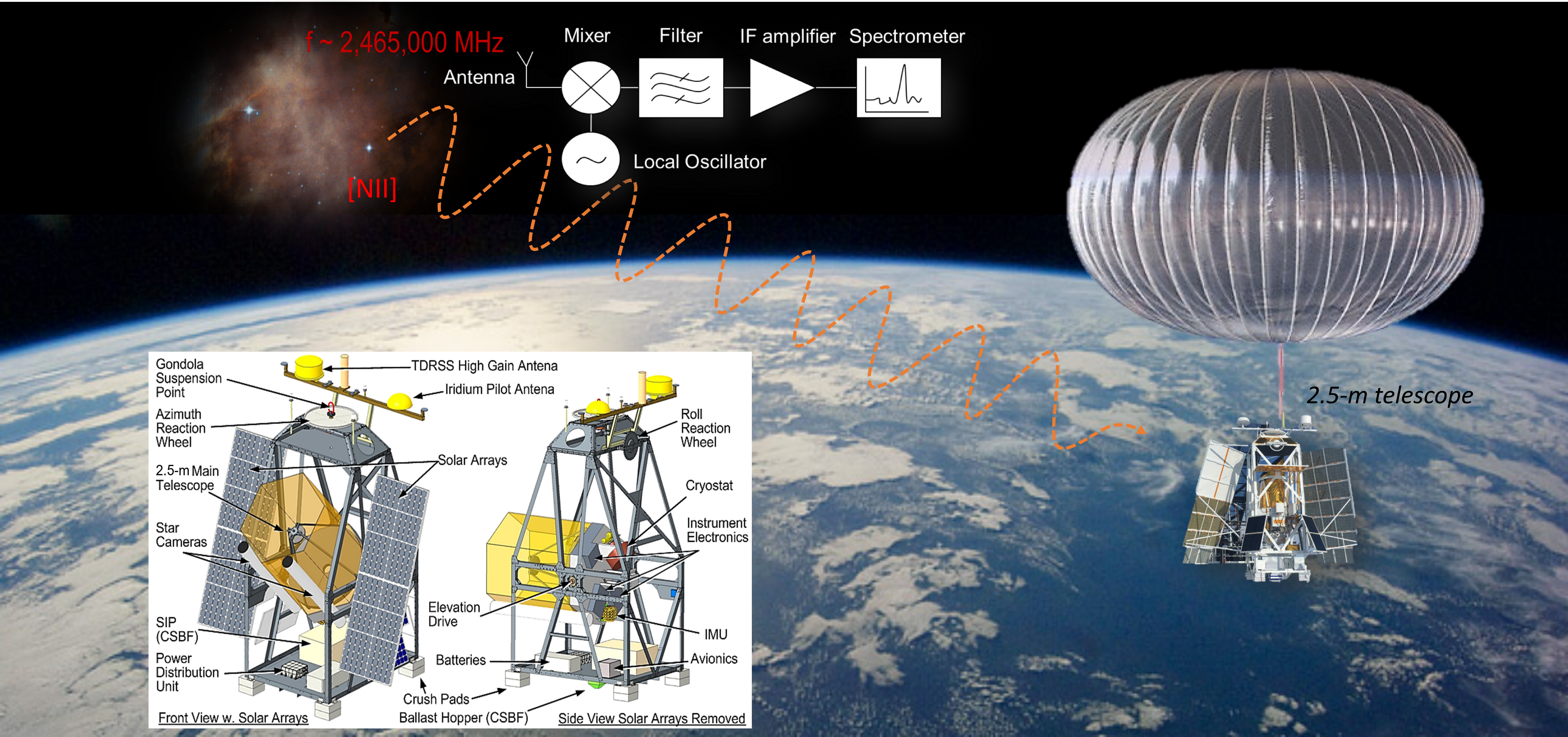
Map area = 0.5 square degrees
Number of spectra = 1.5×10^5
Sensitivity = 0.07K @ 122um , 0.1K @ 205um
SNR= 4 sigma @ 122um ; 10 sigma @ 205um

Carina Nebula



Map area = 1 square degree
Number of spectra = 3×10^5
Sensitivity = 0.1K @ 122um , 0.15K @ 205um
SNR= 3 sigma @ 122um ; 10 sigma @ 205um

ASTHROS "Space-craft" or Gondola



ASTHROS Key Technical Aspects

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2.5m Cassegrain telescope - 8+1 Ni skin on Al honeycomb segments (Media Lario)

- Aggregate rms ≤ 8 µm ε_{Ruze} > 0.5 @ 122µm
- FWHM beam size 20” @205 µm; 12” @ 122 µm

Two 4-pixel arrays of HEB mixers pumped by tunable Schottky diode frequency-multiplied sources

- low band 1.4-1.5 THz; high band 2.4-2.7 THz

Pulse tube refrigerator (Lockheed Martin) w/ 20 mW capacity at 6 K

- (no liquid cryogens)

CMOS ASIC spectrometers (JPL/UCLA)- 1.3 GHz bandwidth/4096 channels –

- 150 g/1.8 W each
- 270km/s coverage and 0.07 km/s resolution at 1.46

Gondola provides < 12” knowledge / 5” pointing stability (based on STO2 experience), power, housekeeping, telemetry (APL)

- Large power and mass margins

ASTHROS Science Overview

- **ASTHROS' 2.5 meter telescope enables observations of the [NII]** 122 μm and 205 μm **in extragalactic sources**
- **We will map, for the first time, the entire disk of the M83** barred-spiral galaxy in spectrally resolved [NII] 122μm & 205μm emission
- **This data will be used to study the distribution of electron densities and star formation** over the entire disk
- **This allows to characterize the effects of large-scale dynamical effects on ionized gas** component of this galaxy under the influence of spiral density waves and a bar

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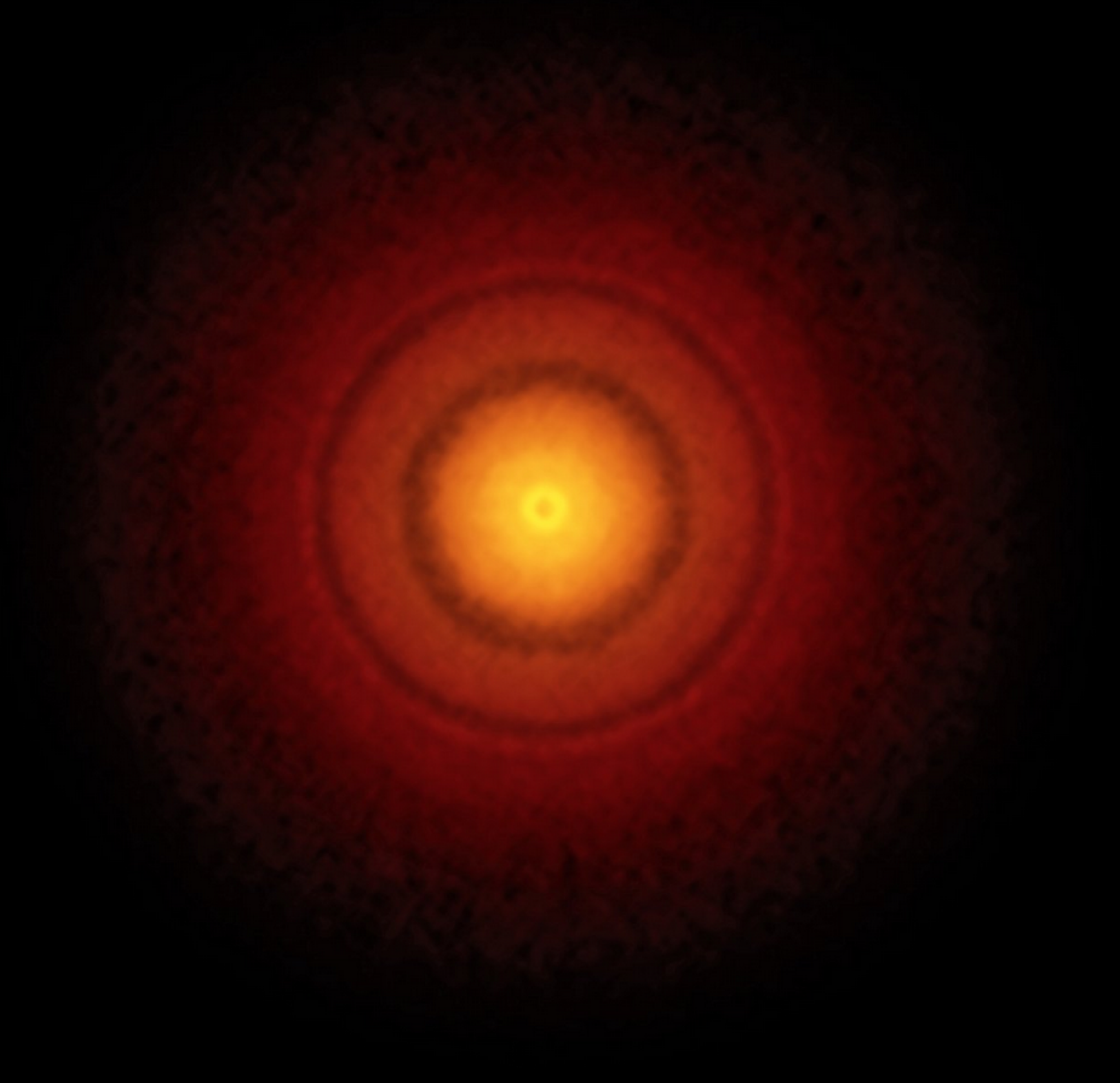
- We also plan to observe for the first time the HD 1-0 line at 2.67 THz in the TW-Hydra protoplanetary disk at high spectral resolution

- **HD is the best tracer of the gas mass of protoplanetary disks**, which is currently not well constrained

- **High-spectral resolution observations are required to determine the mass distribution within the protoplanetary disks**

- **With a model of the rotation curve of the disk (from e.g. ALMA data), a spectrally-resolved measurement of HD 1-0 line will allow us to determine mass distribution within the spatially-unresolved disk**

TW Hydra



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Astrophysics Stratospheric Telescope for High-Resolution Observations at Submillimeter-waves

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THANK YOU!